(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 253 896 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
04.10.2023 Bulletin 2023/40

(21) Application number: **20963563.0**

(22) Date of filing: **27.11.2020**

(51) International Patent Classification (IPC):
F28F 1/32 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F28F 1/32

(86) International application number:
PCT/JP2020/044334

(87) International publication number:
WO 2022/113299 (02.06.2022 Gazette 2022/22)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **MITSUBISHI ELECTRIC CORPORATION**
Chiyoda-ku
Tokyo 100-8310 (JP)

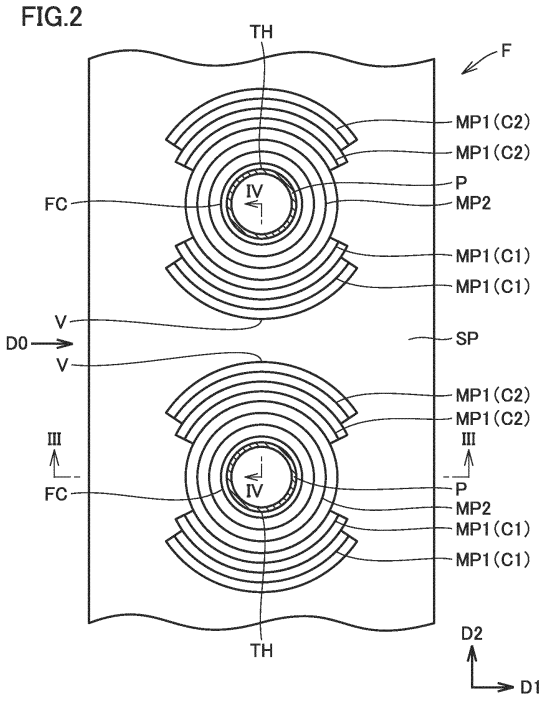
(72) Inventors:
- **YATSUYANAGI, Akira**
  Tokyo 100-8310 (JP)
- **MAEDA, Tsuyoshi**
  Tokyo 100-8310 (JP)
- **YANACHI, Satoru**
  Tokyo 100-8310 (JP)

(74) Representative: **Pfenning, Meinig & Partner mbB**
Patent- und Rechtsanwälte
An der Frauenkirche 20
01067 Dresden (DE)

(54) HEAT EXCHANGER AND REFRIGERATION CYCLE DEVICE

(57) A heat exchanger (HE) includes: a fin (F) extending in a widthwise direction (D1) along an air flow direction (D0) and extending in a longitudinal direction (D2) crossing the air flow direction (D0); and a heat transfer tube (P) passing through the fin (F). The fin (F) includes a planar portion (SP), and a plurality of first protruding portions (MP1) and a plurality of second protruding portions (MP2) that protrude from the planar portion (SP). The plurality of first protruding portions (MP1) include a first projection (C1) curved downward in the longitudinal direction (D2), and a second projection (C2) curved upward in the longitudinal direction (D2). Each of the plurality of second protruding portions (MP2) surrounds a corresponding one of the plurality of through holes (TH). A vertex of the first projection (C1) and a vertex of the second projection (C2) are located at the same position in the widthwise direction (D1).

FIG.2



EP 4 253 896 A1

Description

TECHNICAL FIELD

[0001] The present disclosure relates to a heat exchanger and a refrigeration cycle apparatus.

BACKGROUND ART

[0002] Conventionally, there has been a fin-and-tube-type heat exchanger including a fin and a heat transfer tube passing through the fin. For example, in a heat exchanger described in Japanese Patent Laying-Open No. 2005-77083 (PTL 1), a fin includes a seat portion (planar portion), and peak and valley portions. The seat portion is concentrically formed around an outer circumference of a fin collar to guide air flowing around a heat transfer tube to thereby reduce a wake region. The seat portion is provided with opened front and rear portions. The peak and valley portions are continuously formed between the fin collars to provide airflow variation.

CITATION LIST

PATENT LITERATURE

[0003] PTL 1: Japanese Patent Laying-Open No. 2005-77083

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] In the heat exchanger described in the literature above, the peak and valley portions are continuously formed along an air flow direction, and thus, a boundary layer starting from the peak portion is formed. Therefore, the valley portion forms a dead water region. As a result, a local heat transfer coefficient in the valley portion decreases, which leads to a decrease in heat transfer coefficient of the entire fin. In addition, stress concentrates on the planar portion provided with no peak and valley portions, and thus, the fin has insufficient strength. Furthermore, the water adhering to the fin is hindered from being discharged along a longitudinal direction of the fin.

[0005] The present disclosure has been made in view of the above-described problem, and an object thereof is to provide a heat exchanger and a refrigeration cycle apparatus that can achieve improvements in heat transfer efficiency, strength of a fin, and drainage performance of the water adhering to the fin.

SOLUTION TO PROBLEM

[0006] A heat exchanger of the present disclosure includes: a fin extending in a widthwise direction along an air flow direction and extending in a longitudinal direction crossing the air flow direction; and a heat transfer tube passing through the fin. The fin has a plurality of through holes arranged in the longitudinal direction. The heat transfer tube is inserted in the plurality of through holes. The fin includes a planar portion, and a plurality of first protruding portions and a plurality of second protruding portions that protrude from the planar portion. The plurality of first protruding portions include a first projection located between corresponding through holes of the plurality of through holes and curved downward in the longitudinal direction, and a second projection located between corresponding through holes of the plurality of through holes and curved upward in the longitudinal direction. Each of the plurality of second protruding portions is located between a corresponding one of the plurality of first protruding portions and a corresponding one of the plurality of through holes, and surrounding the corresponding through hole. A vertex of the first projection and a vertex of the second projection are located at the same position in the widthwise direction.

ADVANTAGEOUS EFFECTS OF INVENTION

[0007] According to the heat exchanger of the present disclosure, the first protruding portions and the second protruding portions protrude from the planar portion, and thus, an influence of a dead water region can be suppressed. Therefore, an improvement in heat transfer coefficient of the fin can be achieved. In addition, an improvement in strength of the fin can be achieved by the first protruding portions and the second protruding portions. Furthermore, since the vertex of the first projection and the vertex of the second projection are located at the same position in the widthwise direction, an improvement in drainage performance can be achieved by guiding the water flown from the vertex of the first projection through the vertex of the second projection to both sides.

BRIEF DESCRIPTION OF DRAWINGS

[0008]

Fig. 1 is a perspective view schematically showing a configuration of a heat exchanger according to a first embodiment.
Fig. 2 is a cross-sectional view of a region A in Fig. 1 taken along line II-II.
Fig. 3 is an end view taken along line III-III in Fig. 2.
Fig. 4 is an end view taken along line IV-IV in Fig. 2.
Fig. 5 is a refrigerant circuit diagram showing a refrigeration cycle apparatus according to the first embodiment.
Fig. 6 is a cross-sectional view schematically showing a configuration of a portion of a heat exchanger according to a second embodiment corresponding to Fig. 2.
Fig. 7 is an end view taken along line VII-VII in Fig. 6.
Fig. 8 is an end view taken along line VIII-VIII in Fig. 6.
Fig. 9 is an enlarged view of an IX portion in Fig. 8.

Fig. 10 is a cross-sectional view schematically showing a configuration of a portion of a heat exchanger according to a third embodiment corresponding to Fig. 2.

Fig. 11 is a cross-sectional view taken along line XI-XI in Fig. 10.

Fig. 12 is a cross-sectional view schematically showing a configuration of a portion of a heat exchanger according to a fourth embodiment corresponding to Fig. 2.

Fig. 13 is an end view taken along line XIII-XIII in Fig. 12.

Fig. 14 is a cross-sectional view schematically showing a configuration of a portion of a heat exchanger according to a fifth embodiment corresponding to Fig. 2.

Fig. 15 is an end view taken along line XV-XV in Fig. 14.

Fig. 16 is an end view taken along line XVI-XVI in Fig. 14.

Fig. 17 is a cross-sectional view schematically showing a configuration of a portion of a heat exchanger according to a sixth embodiment corresponding to Fig. 2.

Fig. 18 is an end view taken along line XVIII-XVIII in Fig. 17.

Fig. 19 is an end view taken along line XIX-XIX in Fig. 17.

DESCRIPTION OF EMBODIMENTS

[0009] Embodiments will be described hereinafter with reference to the drawings. In the following description, the same or corresponding portions are denoted by the same reference characters and description thereof will not be repeated.

First Embodiment

[0010] A configuration of a heat exchanger HE according to a first embodiment will be described with reference to Figs. 1 to 4.

[0011] Referring to Figs. 1 and 2, heat exchanger HE includes a fin F and a heat transfer tube P. Fin F extends in a widthwise direction D1 along an air flow direction D0 and extends in a longitudinal direction D2 crossing air flow direction D0. Fin F is formed in a substantially rectangular shape. Heat transfer tube P passes through fin F. Heat transfer tube P is a circular pipe. Fin F has a plurality of through holes TH arranged in longitudinal direction D2. Each of the plurality of through holes TH is formed to have a circular shape. Heat transfer tube P is inserted in the plurality of through holes TH.

[0012] In the present embodiment, heat exchanger HE includes a plurality of fins F. The plurality of fins F are stacked on top of each other at intervals. Heat transfer tube P passes through the plurality of fins F in a direction D3 of stacking of the plurality of fins F. Each of the plurality of fins F has a plurality of through holes TH. The plurality of through holes TH are arranged in longitudinal direction D2 of fin F. The plurality of through holes TH are spaced apart from each other in longitudinal direction D2 of fin F.

[0013] Widthwise direction D1 of fin F is orthogonal to longitudinal direction D2. Widthwise direction D1 of fin F may be a horizontal direction. Longitudinal direction D2 of fin F may be an up-down direction (vertical direction). Direction D3 of stacking of fins F is orthogonal to widthwise direction D1 and longitudinal direction D2 of fin F.

[0014] Heat transfer tube P includes a plurality of heat transfer portions P1 and a plurality of connection portions P2. Each of the plurality of heat transfer portions P 1 passes through the plurality of fins F. Each of the plurality of heat transfer portions P1 is inserted in the plurality of through holes TH in direction D3 of stacking of the plurality of fins F. The plurality of heat transfer portions P1 are formed linearly. Each of the plurality of heat transfer portions P1 extends in direction D3 of stacking of the plurality of fins F.

[0015] Each of the plurality of connection portions P2 is a portion that connects corresponding heat transfer portions P1 of the plurality of heat transfer portions P1 outside the plurality of fins F. Each of the plurality of connection portions P2 is formed to have a U shape. Each of the plurality of connection portions P2 connects heat transfer tubes P that are adjacent to each other in longitudinal direction D2 of fins F. Each of the plurality of connection portions P2 is connected to ends of heat transfer portions P1 in direction D3 of stacking of the plurality of fins F. The plurality of heat transfer portions P1 are disposed in multiple stages in longitudinal direction D2 of fins F. In the present embodiment, the plurality of heat transfer portions P1 are disposed in four stages along longitudinal direction D2 of fins F.

[0016] The plurality of heat transfer portions P1 are connected by the plurality of connection portions P2 as follows. Heat transfer portion P1 in the first stage is connected to heat transfer portion P1 in the second stage by connection portion P2 on the back side in direction D3 of stacking of the plurality of fins F. Heat transfer portion P1 in the second stage is connected to heat transfer portion P1 in the third stage by connection portion P2 on the front side in direction D3 of stacking of the plurality of fins F. Heat transfer portion P1 in the third stage is connected to heat transfer portion P1 in the fourth stage by connection portion P2 on the back side in direction D3 of stacking of the plurality of fins F. In this way, heat transfer tube P is configured to meander in longitudinal direction D2 of fins F.

[0017] A structure of fin F will be described in detail with reference to Figs. 2 to 4.

[0018] Fin F includes a planar portion SP, a plurality of first protruding portions MP1, a plurality of second protruding portions MP2, and a fin collar FC. Planar portion SP is formed in a planar shape. Planar portion SP is formed in a flat plate shape.

[0019] The plurality of first protruding portions MP1 and

the plurality of second protruding portions MP2 protrude from planar portion SP. In the present embodiment, the plurality of first protruding portions MP1 and the plurality of second protruding portions MP2 protrude from planar portion SP in the same direction.

[0020] The plurality of first protruding portions MP1 include a first projection C1 and a second projection C2. First projection C1 is located between corresponding through holes TH of the plurality of through holes TH. First projection C1 is located below a corresponding one of the plurality of through holes TH. First projection C1 is curved downward in longitudinal direction D2 of fin F. Second projection C2 is located between corresponding through holes TH of the plurality of through holes TH. Second projection C2 is located above a corresponding one of the plurality of through holes TH. Second projection C2 is curved upward in longitudinal direction D2 of fin F. In the present embodiment, the plurality of first protruding portions MP1 include a plurality of first projections C1 and a plurality of second projections C2.

[0021] First protruding portion MP1 has a portion extending along longitudinal direction D2 of fin F. First protruding portion MP1 also has a portion extending along widthwise direction D1 of fin F. First protruding portion MP1 is located to be displaced from a center of through hole TH in widthwise direction D1 of fin F. In the present embodiment, first protruding portion MP1 is formed to have an arc shape. In the present embodiment, widths of first protruding portions MP1 are equal to each other.

[0022] The plurality of first protruding portions MP1 are arranged in longitudinal direction D2 of fin F. In the present embodiment, four first protruding portions MP1 are located between two through holes TH in longitudinal direction D2 of fin F. Two first protruding portions MP1 are located on each of the upper side and the lower side of one through hole TH in longitudinal direction D2 of fin F.

[0023] Two first projections C1 located on the lower side of one through hole TH in longitudinal direction D2 of fin F are located to be adjacent to each other in longitudinal direction D2 of fin F. Two second projections C2 located on the upper side of one through hole TH in longitudinal direction D2 of fin F are located to be adjacent to each other in longitudinal direction D2 of fin F.

[0024] Two first projections C1 located to be adjacent to each other are curved toward the same side along longitudinal direction D2. Two second projections C2 located to be adjacent to each other are curved toward the side opposite to two first projections C1 along longitudinal direction D2.

[0025] Two first projections C1 located near upper-side through hole TH of two through holes TH are curved to protrude toward the lower side. Two second projections C2 located near lower-side through hole TH of two through holes TH are curved to protrude toward the upper side. Outer-side first projection C1, of two first projections C1 curved to protrude toward the lower side, is spaced apart from outer-side second projection C2, of two second projections C2 curved to protrude toward the upper side.

[0026] The plurality of first projections C1 are formed to have the same shape. Curvature radii of the plurality of first projections C1 are equal to each other. Centers of curvature of the plurality of first projections C1 are arranged in line with each other in longitudinal direction D2 of fin F. Widths of the plurality of first projections C1 are equal to each other. Lengths of the plurality of first projections C1 are equal to each other.

[0027] Each of the plurality of first projections C1 is formed to have the same shape as that of each of the plurality of second projections C2, except a direction of curving along longitudinal direction D2 of fin F. The plurality of second projections C2 are formed to have the same shape. Curvature radii of the plurality of second projections C2 are equal to each other. Centers of curvature of the plurality of second projections C2 are arranged in line with each other in longitudinal direction D2 of fin F. Widths of the plurality of second projections C2 are equal to each other. Lengths of the plurality of second projections C2 are equal to each other.

[0028] Each of the plurality of first protruding portions MP1 is longer than each of the plurality of second protruding portions MP2 in widthwise direction D1 of fin F. In longitudinal direction D2 of fin F, each of the plurality of first protruding portions MP1 is located between corresponding ones of the plurality of second protruding portions MP2. The respective centers of curvature of the plurality of first protruding portions MP1 are arranged in line with the respective centers of the plurality of second protruding portions MP2 in longitudinal direction D2 of fin F.

[0029] Inner-side first protruding portion MP1, of two first protruding portions MP1 located on the upper side of through hole TH in longitudinal direction D2 of fin F, is adjacent to second protruding portion MP2. Inner-side first protruding portion MP1, of two first protruding portions MP1 located on the lower side of through hole TH in longitudinal direction D2 of fin F, is adjacent to second protruding portion MP2.

[0030] Each of the plurality of second protruding portions MP2 is located between a corresponding one of first protruding portions MP1 and a corresponding one of the plurality of through holes TH. Each of the plurality of second protruding portions MP2 surrounds the corresponding one of the plurality of through holes TH. Second protruding portion MP2 is formed to have an annular shape. Second protruding portion MP2 protrudes from planar portion SP more than first protruding portion MP1.

[0031] The plurality of second protruding portions MP2 are formed to have the same shape. The respective centers of the plurality of second protruding portions MP2 are arranged in line in longitudinal direction D2 of fin F. The plurality of second protruding portions MP2 have the same shape. The plurality of second protruding portions MP2 have the same diameter.

[0032] A vertex V of first projection C1 and a vertex V of second projection C2 are located at the same position

in widthwise direction D1 of fin F. Vertexes V of first projection C1 and second projection C2 are portions that protrude most along longitudinal direction D2 of fin F. Vertex V of first projection C1 and vertex V of second projection C2 are arranged in line in longitudinal direction D2 of fin F.

[0033] First protruding portion MP1 is narrower in width than second protruding portion MP2. That is, the width of each of the plurality of first protruding portions MP1 is narrower than the width of each of the plurality of second protruding portions MP2.

[0034] A top of a protrusion of first protruding portion MP1 is located at a center of the width of first protruding portion MP1. A top of a protrusion of second protruding portion MP2 is located at a center of the width of second protruding portion MP2.

[0035] First protruding portion MP1 and second protruding portion MP2 are lower in protruding height from planar portion SP than fin collar FC.

[0036] Fin collar FC is formed to have a cylindrical shape. Heat transfer tube P is inserted in fin collar FC. The outer circumferential surface of heat transfer tube P fits onto the inner circumferential surface of fin collar FC. Fin collar FC protrudes from planar portion SP. In the present embodiment, fin collar FC protrudes from planar portion SP in the same direction as that of first protruding portion MP1 and second protruding portion MP2.

[0037] Fin collar FC includes a circumferential wall and a flange. The circumferential wall protrudes from planar portion SP. The flange extends outward from the circumferential wall. The flange is provided at the edge of the circumferential wall opposite to planar portion SP. In the present embodiment, fin F includes a plurality of fin collars FC.

[0038] A configuration of a refrigeration cycle apparatus 100 including heat exchanger HE according to the first embodiment will be described with reference to Fig. 5. Refrigeration cycle apparatus 100 is, for example, an air conditioner, a refrigerating machine and the like. In the first embodiment, an air conditioner is described as an example of refrigeration cycle apparatus 100. Refrigeration cycle apparatus 100 includes a refrigerant circuit RC, refrigerant, a controller CD, and air blowers 6 and 7. Refrigeration cycle apparatus 100 includes a refrigerant circulation device RCD. Refrigerant circulation device RCD is configured to circulate refrigerant for performing heat exchange with air in heat exchanger HE. In the first embodiment, refrigeration cycle apparatus 100 including a compressor 1 incorporated therein as refrigerant circulation device RCD is described. Refrigerant circulation device RCD may be a refrigerant pump.

[0039] Refrigerant circuit RC includes compressor 1, a four-way valve 2, an outdoor heat exchanger 3, a pressure reducing valve 4, and an indoor heat exchanger 5. Heat exchanger HE described above may be applied to at least one of outdoor heat exchanger 3 and indoor heat exchanger 5. Compressor 1, four-way valve 2, outdoor heat exchanger 3, pressure reducing valve 4, and indoor heat exchanger 5 are connected by a pipe. Refrigerant circuit RC is configured to circulate the refrigerant. Refrigerant circuit RC is configured to perform a refrigeration cycle in which the refrigerant circulates while changing its phase.

[0040] Compressor 1, four-way valve 2, outdoor heat exchanger 3, pressure reducing valve 4, controller CD, and air blower 6 are housed in an outdoor unit 101. Indoor heat exchanger 5 and air blower 7 are housed in an indoor unit 102.

[0041] Refrigerant circuit RC is configured such that the refrigerant circulates in the order of compressor 1, four-way valve 2, outdoor heat exchanger (condenser) 3, pressure reducing valve 4, indoor heat exchanger (evaporator) 5, and four-way valve 2 during a cooling operation. Refrigerant circuit RC is configured such that the refrigerant circulates in the order of compressor 1, four-way valve 2, indoor heat exchanger (condenser) 5, pressure reducing valve 4, outdoor heat exchanger (evaporator) 3, and four-way valve 2 during a heating operation.

[0042] The refrigerant flows through refrigerant circuit RC in the order of compressor 1, the condenser, pressure reducing valve 4, and the evaporator.

[0043] Controller CD is configured to control each device of refrigeration cycle apparatus 100 by, for example, performing calculations or providing instructions. Controller CD is electrically connected to compressor 1, four-way valve 2, pressure reducing valve 4, air blowers 6 and 7, and the like to control the operations of these components.

[0044] Compressor 1 is configured to compress the refrigerant for performing heat exchange with the air in heat exchanger HE. Compressor 1 is configured to compress the sucked refrigerant and discharge the compressed refrigerant. Compressor 1 may be configured to have a variable capacity. Compressor 1 may be configured to have a capacity changing through the adjustment of the rotation speed of compressor 1 based on an instruction provided from controller CD.

[0045] Four-way valve 2 is configured to switch a flow of the refrigerant such that the refrigerant compressed by compressor 1 flows to outdoor heat exchanger 3 or indoor heat exchanger 5. Four-way valve 2 is configured such that during the cooling operation, the refrigerant discharged from compressor 1 flows to outdoor heat exchanger (condenser) 3. Four-way valve 2 is configured such that during the heating operation, the refrigerant discharged from compressor 1 flows to indoor heat exchanger (evaporator) 5.

[0046] Outdoor heat exchanger 3 is configured to exchange heat between the refrigerant flowing inside outdoor heat exchanger 3 and the air flowing outside outdoor heat exchanger 3. Outdoor heat exchanger 3 is configured to function as a condenser that condenses the refrigerant during the cooling operation, and function as an evaporator that evaporates the refrigerant during the heating operation.

[0047] Pressure reducing valve 4 is configured to reduce pressure by expanding the refrigerant condensed by the condenser. Pressure reducing valve 4 is configured to reduce the pressure of the refrigerant condensed by outdoor heat exchanger (condenser) 3 during the cooling operation, and reduce the pressure of the refrigerant condensed by indoor heat exchanger (evaporator) 5 during the heating operation. Pressure reducing valve 4 is, for example, a solenoid valve.

[0048] Indoor heat exchanger 5 is configured to exchange heat between the refrigerant flowing inside indoor heat exchanger 5 and the air flowing outside indoor heat exchanger 5. Indoor heat exchanger 5 is configured to function as an evaporator that evaporates the refrigerant during the cooling operation, and function as a condenser that condenses the refrigerant during the heating operation.

[0049] Air blower 6 is configured to blow the outdoor air to outdoor heat exchanger 3. That is, air blower 6 is configured to supply the air to outdoor heat exchanger 3. Air blower 6 may be configured to adjust the amount of heat exchange between the refrigerant and the air by adjusting a rotation speed of air blower 6 based on an instruction provided from controller CD, thereby adjusting an amount of heat exchange between the refrigerant and the air.

[0050] Air blower 7 is configured to blow the indoor air to indoor heat exchanger 5. That is, air blower 7 is configured to supply the air to indoor heat exchanger 5. Air blower 7 may be configured to adjust the amount of the air flowing around indoor heat exchanger 5 through the adjustment of the rotation speed of air blower 7 based on an instruction provided from controller CD, thereby adjusting an amount of heat exchange between the refrigerant and the air.

[0051] Next, the operation of refrigeration cycle apparatus 100 will be described with reference to Fig. 5. A solid arrow in Fig. 5 indicates a flow of the refrigerant during the cooling operation, and a dashed arrow in Fig. 5 indicates a flow of the refrigerant during the heating operation.

[0052] Refrigeration cycle apparatus 100 can selectively perform the cooling operation and the heating operation. During the cooling operation, the refrigerant circulates in refrigerant circuit RC in the order of compressor 1, four-way valve 2, outdoor heat exchanger 3, pressure reducing valve 4, indoor heat exchanger 5, and four-way valve 2. During the cooling operation, outdoor heat exchanger 3 functions as a condenser. Heat is exchanged between the refrigerant flowing through outdoor heat exchanger 3 and the air blown by air blower 6. During the cooling operation, indoor heat exchanger 5 functions as an evaporator. Heat is exchanged between the refrigerant flowing through indoor heat exchanger 5 and the air blown by air blower 7.

[0053] During the heating operation, the refrigerant circulates through refrigerant circuit RC in the order of compressor 1, four-way valve 2, indoor heat exchanger 5, pressure reducing valve 4, outdoor heat exchanger 3, and four-way valve 2. During the heating operation, indoor heat exchanger 5 functions as a condenser. Heat is exchanged between the refrigerant flowing through indoor heat exchanger 5 and the air blown by air blower 7. During the heating operation, outdoor heat exchanger 3 functions as an evaporator. Heat is exchanged between the refrigerant flowing through outdoor heat exchanger 3 and the air blown by air blower 6.

[0054] Refrigeration cycle apparatus 100 can also perform defrosting operation. During the defrosting operation, the refrigerant temporarily circulates in refrigerant circuit RC in the same order as that during the cooling operation. As a result, frost that formed on the evaporator is melted by the heat of the refrigerant. In this way, the frost that formed on the evaporator is removed.

[0055] Next, a function and effect of the first embodiment will be described.

[0056] In heat exchanger HE according to the first embodiment, first protruding portions MP1 and second protruding portions MP2 protrude from planar portion SP, and thus, an influence of a dead water region can be suppressed. Therefore, an improvement in heat transfer coefficient of fin F can be achieved. In addition, an improvement in strength of fin F can be achieved by first protruding portions MP1 and second protruding portions MP2. Furthermore, since vertex V of first projection C1 and vertex V of second projection C2 are located at the same position in widthwise direction D1 of fin F, an improvement in drainage performance can be achieved by guiding the water flown from vertex V of first projection C1 through vertex V of second projection C2 to both sides. This water may be condensed water, or may be defrosting water generated during defrosting.

[0057] In heat exchanger HE according to the first embodiment, first protruding portion MP1 is narrower in width than second protruding portion MP2. Therefore, by guiding the water accumulated in second protruding portion MP2 to first protruding portion MP1 due to surface tension, an improvement in drainage performance can be achieved.

Second Embodiment

[0058] Unless otherwise specified, heat exchanger HE and refrigeration cycle apparatus 100 according to a second embodiment have the same configuration, operation, and function and effect as those of heat exchanger HE and refrigeration cycle apparatus 100 according to the first embodiment.

[0059] A structure of fin F of heat exchanger HE according to the second embodiment will be described with reference to Figs. 6 to 9.

[0060] As shown in Figs. 6 to 8, in the present embodiment, a top of a protrusion of first protruding portion MP1 is located outside a center of a width of first protruding portion MP1. A top of a protrusion of second protruding portion MP2 is located outside a center of a width of sec-

ond protruding portion MP2. In at least one of first protruding portion MP1 and second protruding portion MP2, the top of the protrusion may be located outside the center of the width.

[0061] As shown in Figs. 8 and 9, at least one of first protruding portion MP1 and second protruding portion MP2 includes an inner inclined surface IS and an outer inclined surface OS. Inner inclined surface IS is located to face a corresponding one of the plurality of through holes TH. Outer inclined surface OS is located opposite to the corresponding one of the plurality of through holes with respect to inner inclined surface IS. An inner inclination angle $\theta 1$ formed by inner inclined surface IS with respect to planar portion SP is smaller than an outer inclination angle $\theta 2$ formed by outer inclined surface OS with respect to planar portion SP.

[0062] Next, the function and effect of the second embodiment will be described.

[0063] In heat exchanger HE according to the second embodiment, inner inclination angle $\theta 1$ formed by inner inclined surface IS with respect to planar portion SP is smaller than outer inclination angle $\theta 2$ formed by outer inclined surface OS with respect to planar portion SP. Therefore, accumulation of the water adhering to fin F in inner inclined surface IS can be suppressed. Therefore, an improvement in drainage performance can be achieved.

Third Embodiment

[0064] Unless otherwise specified, heat exchanger HE and refrigeration cycle apparatus 100 according to a third embodiment have the same configuration, operation, and function and effect as those of heat exchanger HE and refrigeration cycle apparatus 100 according to the second embodiment.

[0065] A structure of fin F of heat exchanger HE according to the third embodiment will be described with reference to Figs. 10 and 11.

[0066] First protruding portion MP1 is inclined such that a protruding height from planar portion SP becomes lower toward a center of first protruding portion MP1 in widthwise direction D1 of fin F. Second protruding portion MP2 is inclined such that a protruding height from planar portion SP becomes lower toward a center of second protruding portion MP2 in widthwise direction D1 of fin F.

[0067] At least one of first protruding portion MP1 and second protruding portion MP2 may be inclined such that the protruding height from planar portion SP becomes lower toward the center of the at least one of first protruding portion MP1 and second protruding portion MP2 in widthwise direction D1 of fin F.

[0068] Next, the function and effect of the third embodiment will be described.

[0069] In heat exchanger HE according to the third embodiment, at least one of first protruding portion MP1 and second protruding portion MP2 is inclined such that the protruding height from planar portion SP becomes lower toward the center of the at least one of first protruding portion MP1 and second protruding portion MP2 in widthwise direction D1 of fin F. Therefore, when the water adhering to fin F falls downward, hindrance of the fall of the water adhering to fin F in at least one of first protruding portion MP1 and second protruding portion MP2 can be suppressed. Therefore, an improvement in drainage performance can be achieved.

Fourth Embodiment

[0070] Unless otherwise specified, heat exchanger HE and refrigeration cycle apparatus 100 according to a fourth embodiment have the same configuration, operation, and function and effect as those of heat exchanger HE and refrigeration cycle apparatus 100 according to the second embodiment.

[0071] A structure of fin F of heat exchanger HE according to the fourth embodiment will be described with reference to Figs. 12 and 13.

[0072] Fin F includes an intermediate protruding portion MM. Intermediate protruding portion MM protrudes from planar portion SP. Intermediate protruding portion MM protrudes from planar portion SP in the same direction as that of first protruding portion MP1 and second protruding portion MP2.

[0073] Intermediate protruding portion MM extends linearly in longitudinal direction D2 of fin F. Intermediate protruding portion MM connects the vertex of first projection C1 and the vertex of second projection C2. Intermediate protruding portion MM is narrower in width than first protruding portion MP1.

[0074] Next, the function and effect of the fourth embodiment will be described.

[0075] In heat exchanger HE according to the fourth embodiment, intermediate protruding portion MM connects the vertex of first projection C1 and the vertex of second projection C2. Therefore, intermediate protruding portion MM functions as a drainage path, and thus, accumulation of the water adhering to the fin in first protruding portion MP1 can be suppressed. Therefore, an improvement in drainage performance can be achieved.

Fifth Embodiment

[0076] Unless otherwise specified, heat exchanger HE and refrigeration cycle apparatus 100 according to a fifth embodiment have the same configuration, operation, and function and effect as those of heat exchanger HE and refrigeration cycle apparatus 100 according to the second embodiment.

[0077] A structure of fin F of heat exchanger HE according to the fifth embodiment will be described with reference to Figs. 14 to 16.

[0078] Fin F includes a third protruding portion MP3. Fin F protrudes from planar portion SP. Third protruding portion MP3 protrudes from planar portion SP in the same direction as that of first protruding portion MP1 and sec-

ond protruding portion MP2. Third protruding portion MP3 extends linearly in longitudinal direction D2 of fin F. Third protruding portion MP3 extends continuously from one end to the other end in longitudinal direction D2 of fin F.

[0079] Third protruding portion MP3 is located outside first protruding portion MP1 in widthwise direction D1 of fin F. Third protruding portion MP3 is located outside second protruding portion MP2 in widthwise direction D1 of fin F. Third protruding portion MP3 is narrower in width than first protruding portion MP1 and second protruding portion MP2.

[0080] In the present embodiment, fin F includes a plurality of third protruding portions MP3. The plurality of third protruding portions MP3 extend in parallel to each other in longitudinal direction D2 of fin F. The plurality of third protruding portions MP3 are located at both ends in widthwise direction D1 of fin F. The plurality of third protruding portions MP3 are located to sandwich the plurality of first protruding portions MP1 and the plurality of second protruding portions MP2. Third protruding portions MP3 are spaced apart from first protruding portions MP1 and second protruding portions MP2 in widthwise direction D1 of fin F. Widths of the plurality of third protruding portions MP3 are equal to each other.

[0081] Next, the function and effect of the fifth embodiment will be described.

[0082] In heat exchanger HE according to the fifth embodiment, third protruding portion MP3 extends linearly in longitudinal direction D2 of fin F. Therefore, an improvement in strength of fin F in longitudinal direction D2 of fin F can be achieved by third protruding portion MP3.

[0083] Third protruding portion MP3 is located outside first protruding portion MP1 in widthwise direction D1 of fin F and is narrower in width than first protruding portion MP1 and second protruding portion MP2. Therefore, the water adhering to fin F can be guided from first protruding portion MP1 to third protruding portion MP3 due to surface tension. The water adhering to fin F can then flow along third protruding portion MP3. Therefore, an improvement in drainage performance can be achieved.

Sixth Embodiment

[0084] Unless otherwise specified, heat exchanger HE and refrigeration cycle apparatus 100 according to a sixth embodiment have the same configuration, operation, and function and effect as those of heat exchanger HE and refrigeration cycle apparatus 100 according to the fifth embodiment.

[0085] A structure of fin F of heat exchanger HE according to the sixth embodiment will be described with reference to Figs. 17 to 19.

[0086] First projection C1 is located at a position that is more distant from third protruding portion MP3 than second projection C2 in widthwise direction D1 of fin F. First projection C1 is shorter than second projection C2 in widthwise direction D1 of fin F.

[0087] Next, the function and effect of the sixth embodiment will be described.

[0088] In heat exchanger HE according to the sixth embodiment, first projection C1 is located at a position that is more distant from third protruding portion MP3 than second projection C2 in widthwise direction D1 of fin F. Therefore, the water adhering to fin F is easily guided from second projection C2 to third protruding portion MP3. In addition, movement of the water adhering to fin F from third protruding portion MP3 to first projection C1 can be suppressed. Therefore, an improvement in drainage performance can be achieved.

[0089] It should be understood that the embodiments disclosed herein are illustrative and non-restrictive in every respect. The scope of the present disclosure is defined by the terms of the claims, rather than the description above, and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

REFERENCE SIGNS LIST

[0090] 1 compressor; 2 four-way valve; 3 outdoor heat exchanger; 4 pressure reducing valve; 5 indoor heat exchanger; 100 refrigeration cycle apparatus; C1 first projection; C2 second projection; D0 air flow direction; D1 widthwise direction; D2 longitudinal direction; F fin; HE heat exchanger; IS inner inclined surface; MP1 first protruding portion; MP2 second protruding portion; MP3 third protruding portion; OS outer inclined surface; P heat transfer tube; SP planar portion; TH through hole; V vertex.

Claims

1. A heat exchanger comprising:

a fin extending in a widthwise direction along an air flow direction and extending in a longitudinal direction crossing the air flow direction; and
a heat transfer tube passing through the fin,
the fin having a plurality of through holes arranged in the longitudinal direction,
the heat transfer tube being inserted in the plurality of through holes,
the fin comprising a planar portion, and a plurality of first protruding portions and a plurality of second protruding portions that protrude from the planar portion,
the plurality of first protruding portions comprising

a first projection located between corresponding through holes of the plurality of through holes and curved downward in the longitudinal direction, and
a second projection located between corresponding through holes of the plurality of

through holes and curved upward in the longitudinal direction,

each of the plurality of second protruding portions being located between a corresponding one of the plurality of first protruding portions and a corresponding one of the plurality of through holes, and surrounding the corresponding through hole, and
a vertex of the first projection and a vertex of the second projection being located at the same position in the widthwise direction.

2. The heat exchanger according to claim 1, wherein the first protruding portion is narrower in width than the second protruding portion.

3. The heat exchanger according to claim 1 or 2, wherein

at least one of the first protruding portion and the second protruding portion includes an inner inclined surface located to face a corresponding one of the plurality of through holes, and an outer inclined surface located opposite to the corresponding one of the plurality of through holes with respect to the inner inclined surface, and
an inner inclination angle formed by the inner inclined surface with respect to the planar portion is smaller than an outer inclination angle formed by the outer inclined surface with respect to the planar portion.

4. The heat exchanger according to claim 3, wherein at least one of the first protruding portion and the second protruding portion is inclined such that a protruding height from the planar portion becomes lower toward a center of the at least one of the first protruding portion and the second protruding portion in the widthwise direction.

5. The heat exchanger according to any one of claims 1 to 4, wherein

the fin includes an intermediate protruding portion protruding from the planar portion, and
the intermediate protruding portion extends linearly in the longitudinal direction and connects the vertex of the first projection and the vertex of the second projection.

6. The heat exchanger according to any one of claims 1 to 5, wherein

the fin includes a third protruding portion protruding from the planar portion, and
the third protruding portion extends linearly in the longitudinal direction.

7. The heat exchanger according to claim 6, wherein the third protruding portion is located outside the first protruding portion in the widthwise direction and is narrower in width than the first protruding portion and the second protruding portion.

8. The heat exchange according to claim 6 or 7, wherein the first projection is located at a position that is more distant from the third protruding portion than the second projection in the widthwise direction.

9. A refrigeration cycle apparatus comprising:

the heat exchanger according to any one of claims 1 to 8; and
a refrigerant circulation device,
the refrigerant circulation device being configured to circulate refrigerant for performing heat exchange with air in the heat exchanger.

FIG.1

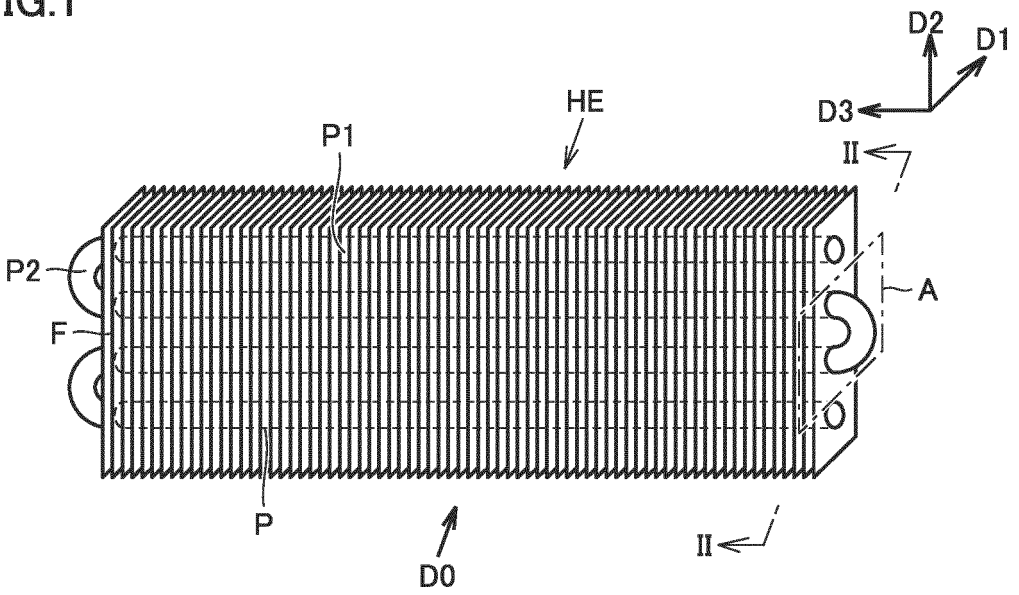


FIG.2

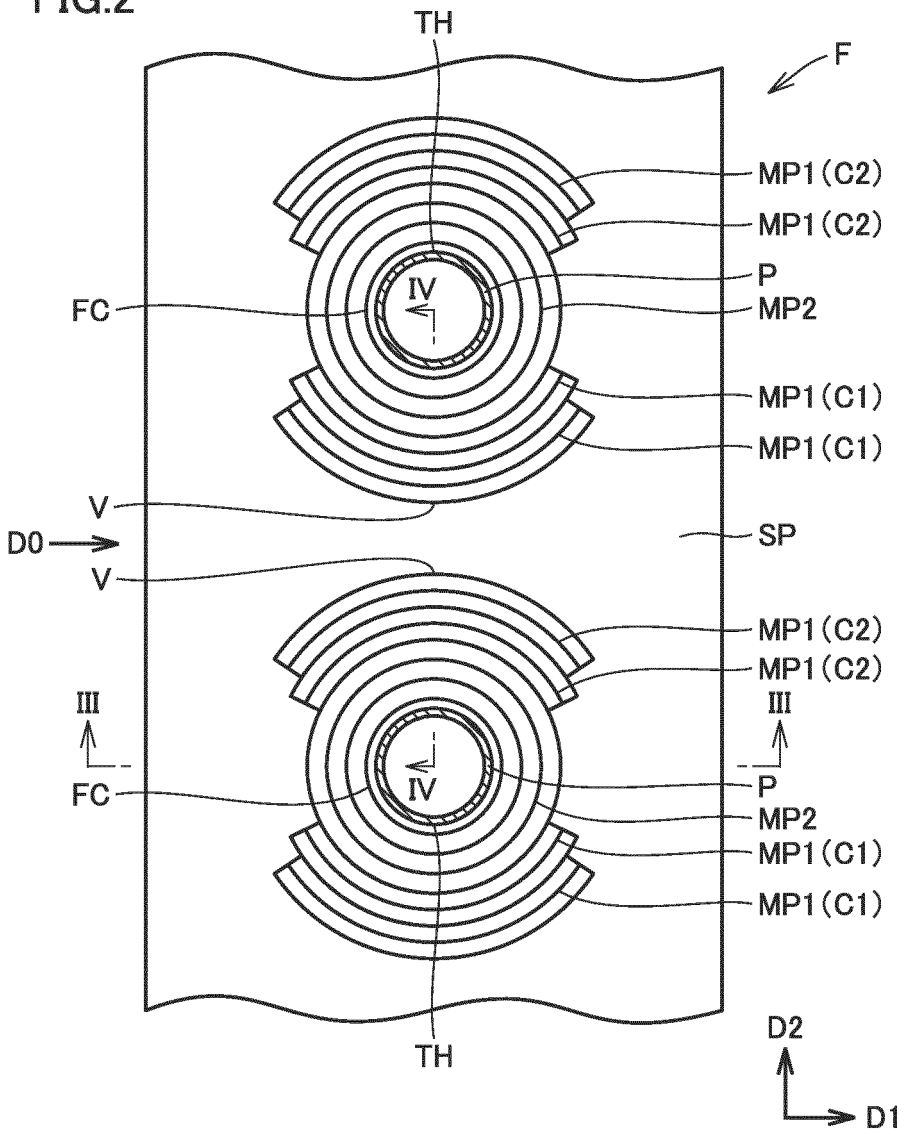

TH
F
MP1(C2)
MP1(C2)
P
IV
FC
MP2
MP1(C1)
MP1(C1)
V
D0
SP
V
MP1(C2)
MP1(C2)
III
III
IV
FC
P
MP2
MP1(C1)
MP1(C1)
TH
D2
D1

FIG.3

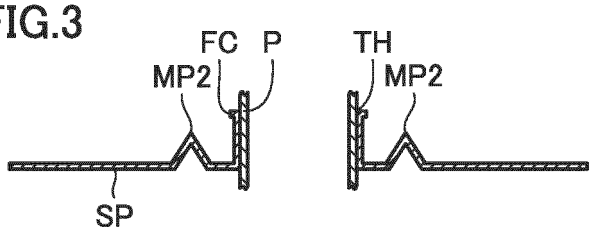


FIG.4

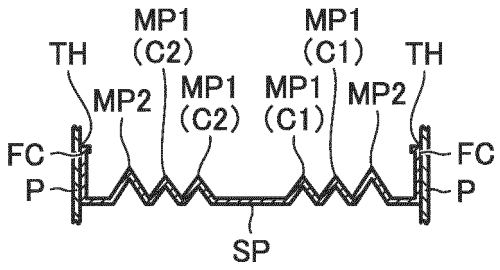


FIG.5

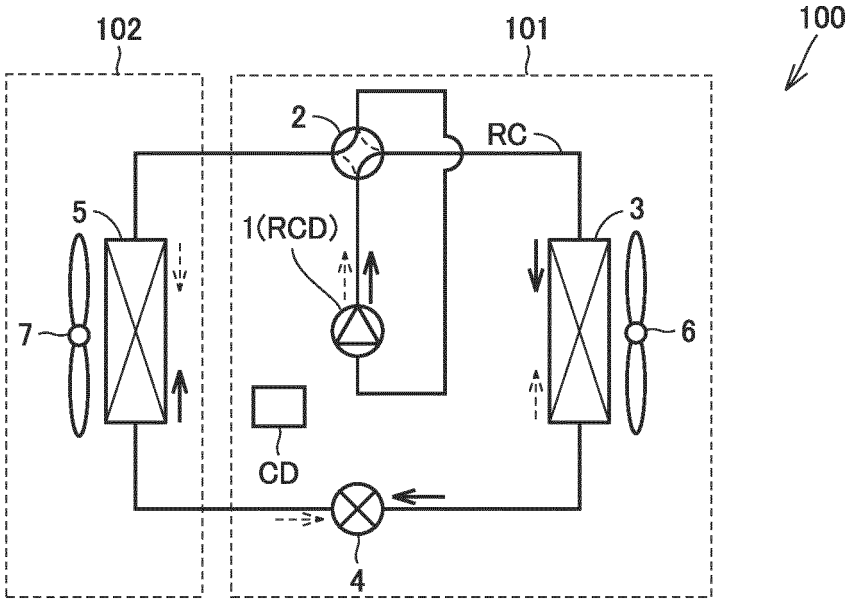


FIG.6

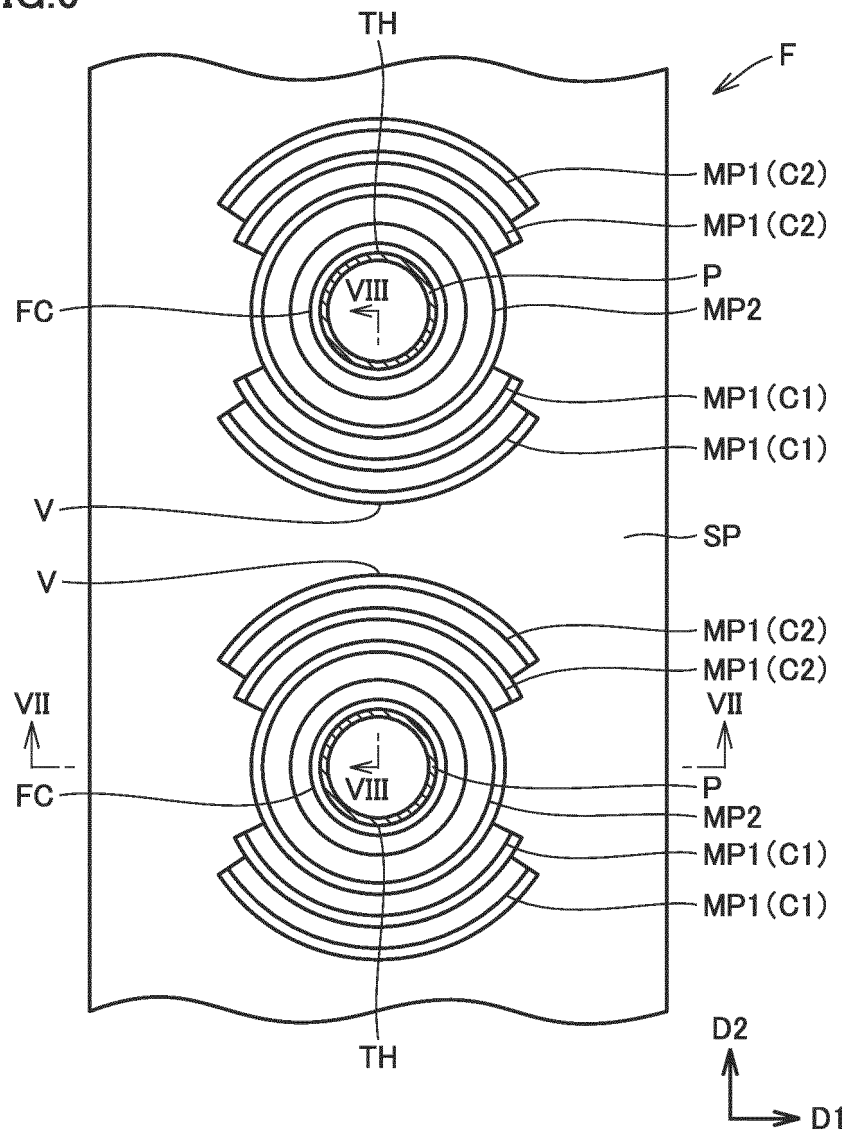

TH
F
MP1(C2)
MP1(C2)
P
VIII
FC
MP2
MP1(C1)
MP1(C1)
V
SP
V
MP1(C2)
MP1(C2)
VII
VII
FC
VIII
P
MP2
MP1(C1)
MP1(C1)
TH
D2
D1

FIG.7

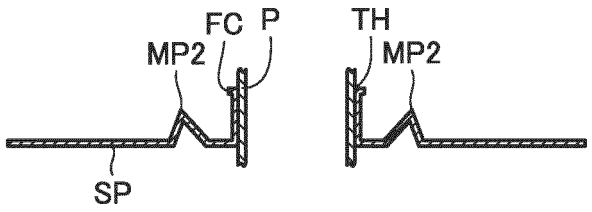


FIG.8

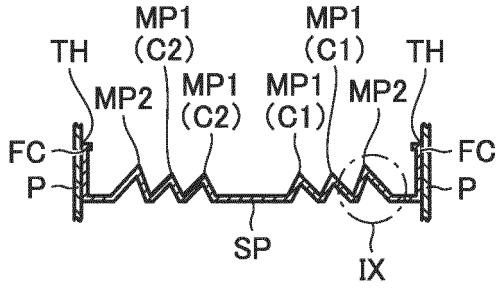


FIG.9

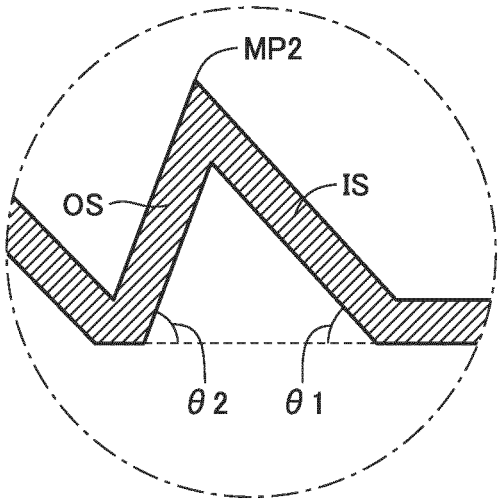


FIG.10

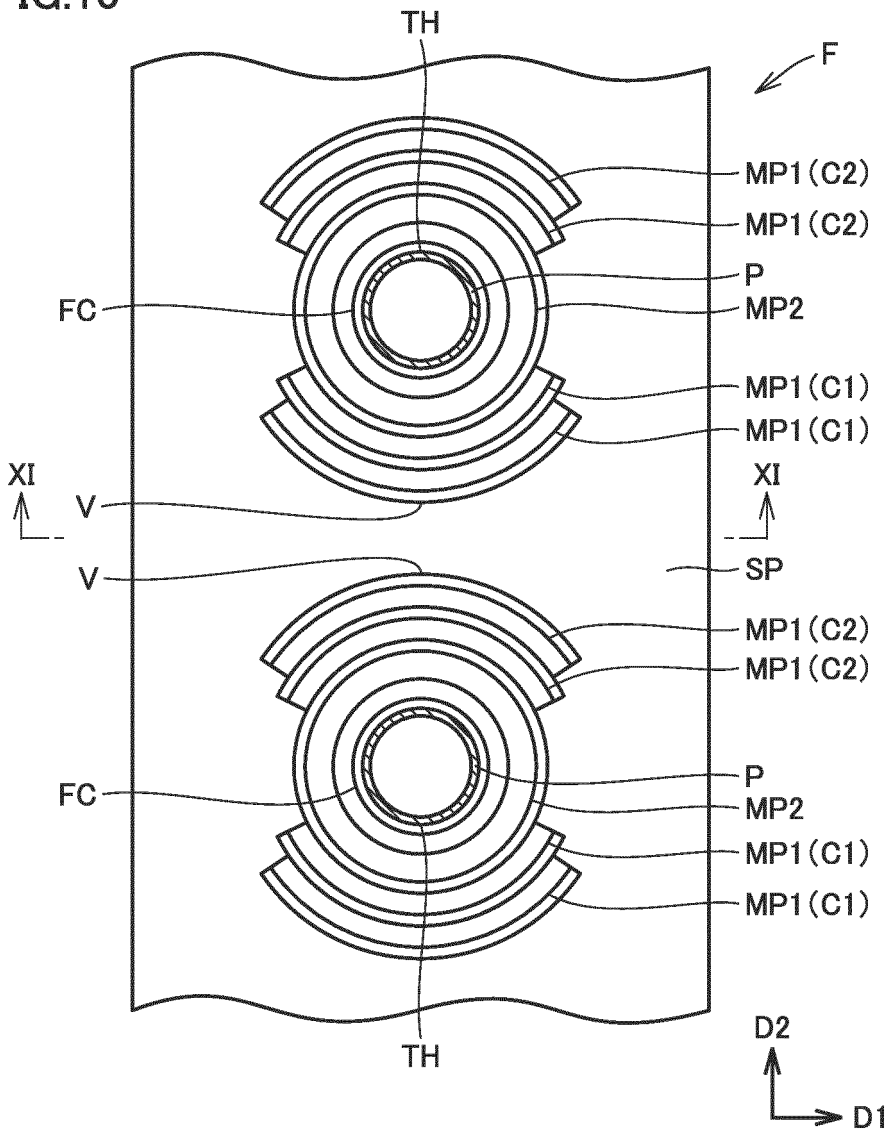

TH
F
MP1(C2)
MP1(C2)
P
FC
MP2
MP1(C1)
MP1(C1)
XI
V
XI
V
SP
MP1(C2)
MP1(C2)
FC
P
MP2
MP1(C1)
MP1(C1)
TH
D2
D1

FIG.11

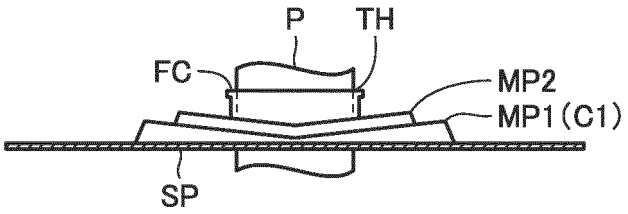


FIG.12

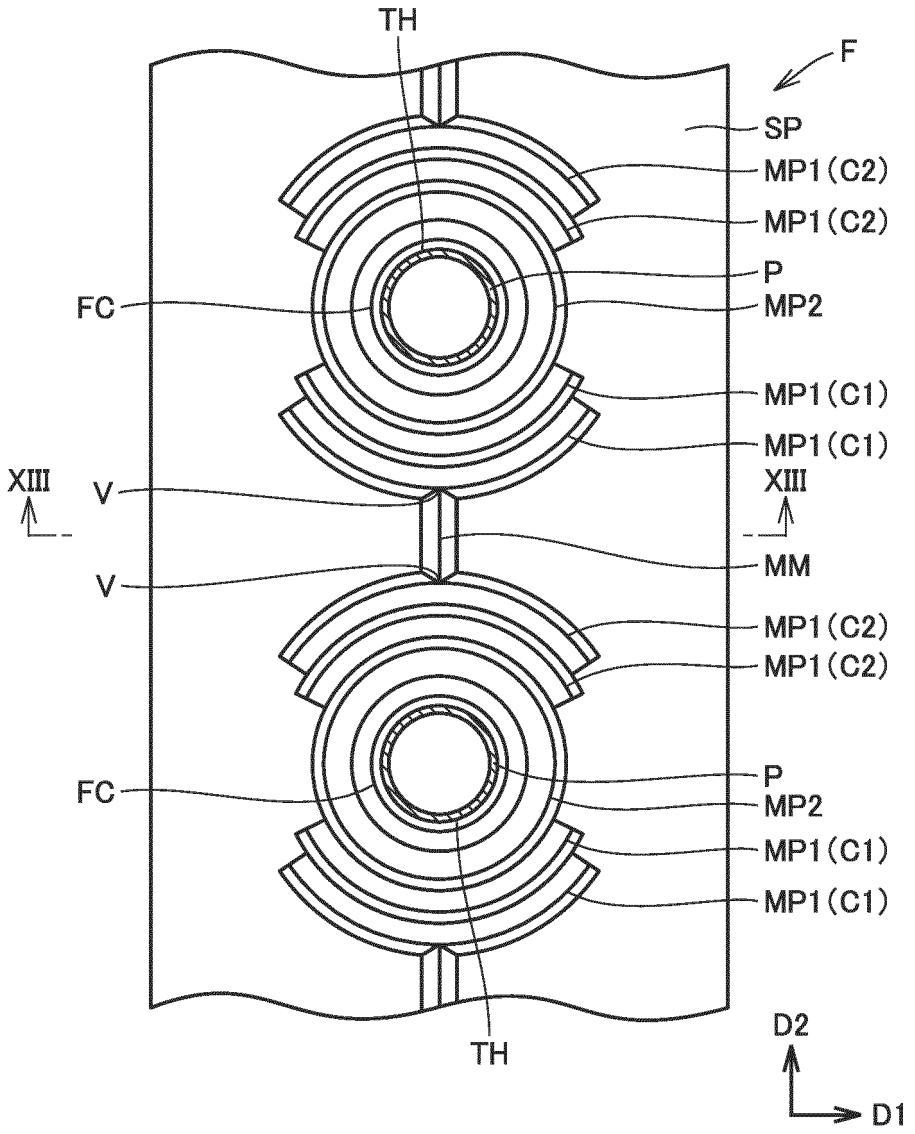

TH
F
SP
MP1(C2)
MP1(C2)
P
FC
MP2
MP1(C1)
MP1(C1)
XIII
V
XIII
MM
V
MP1(C2)
MP1(C2)
P
FC
MP2
MP1(C1)
MP1(C1)
TH
D2
D1

FIG.13

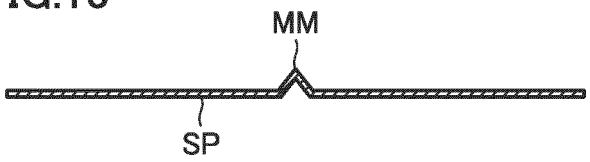


FIG.14

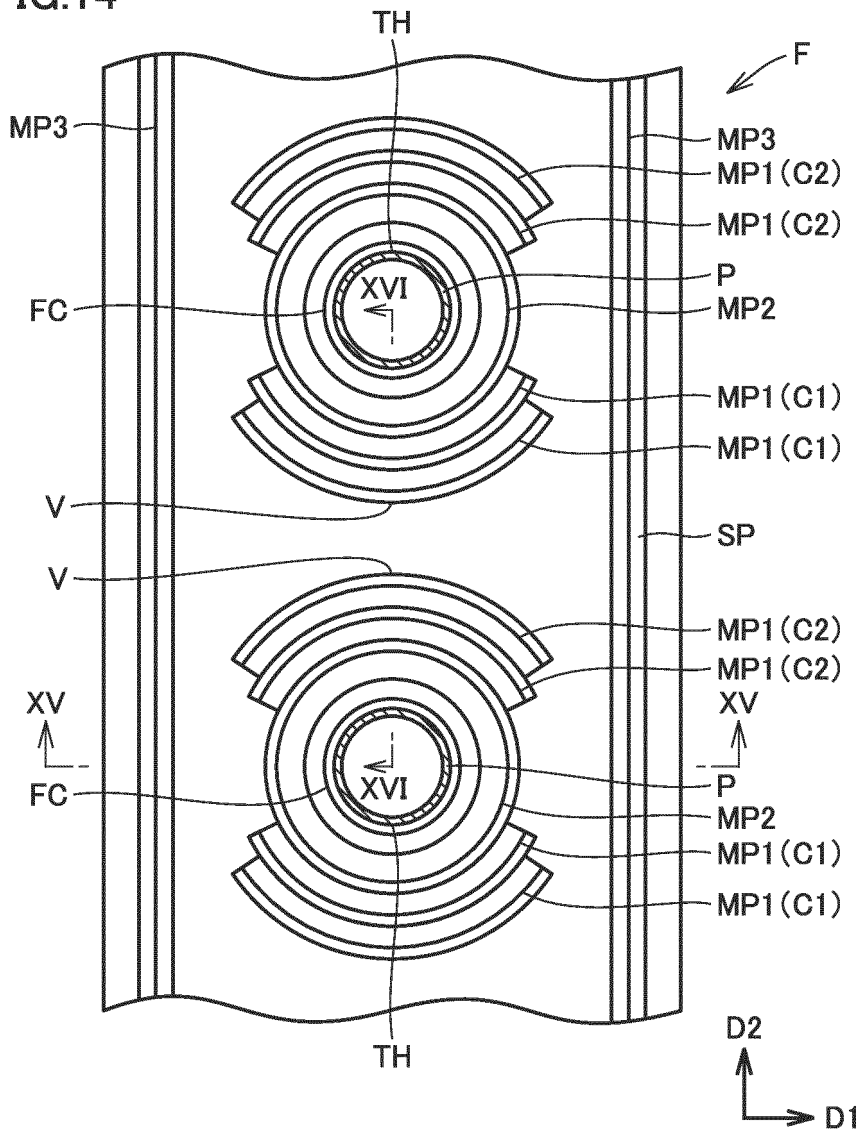

TH
F
MP3
MP3
MP1(C2)
MP1(C2)
P
XVI
FC
MP2
MP1(C1)
MP1(C1)
V
SP
V
MP1(C2)
MP1(C2)
XV
XV
XVI
FC
P
MP2
MP1(C1)
MP1(C1)
TH
D2
D1

FIG.15

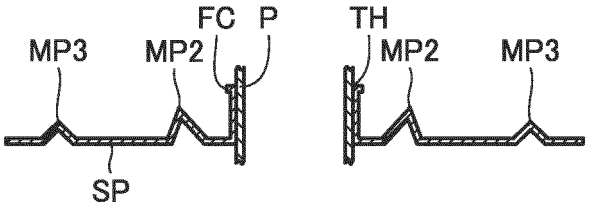


FIG.16

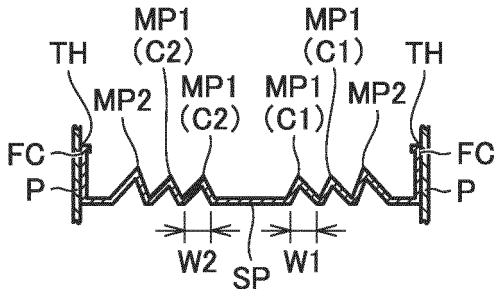


FIG.17

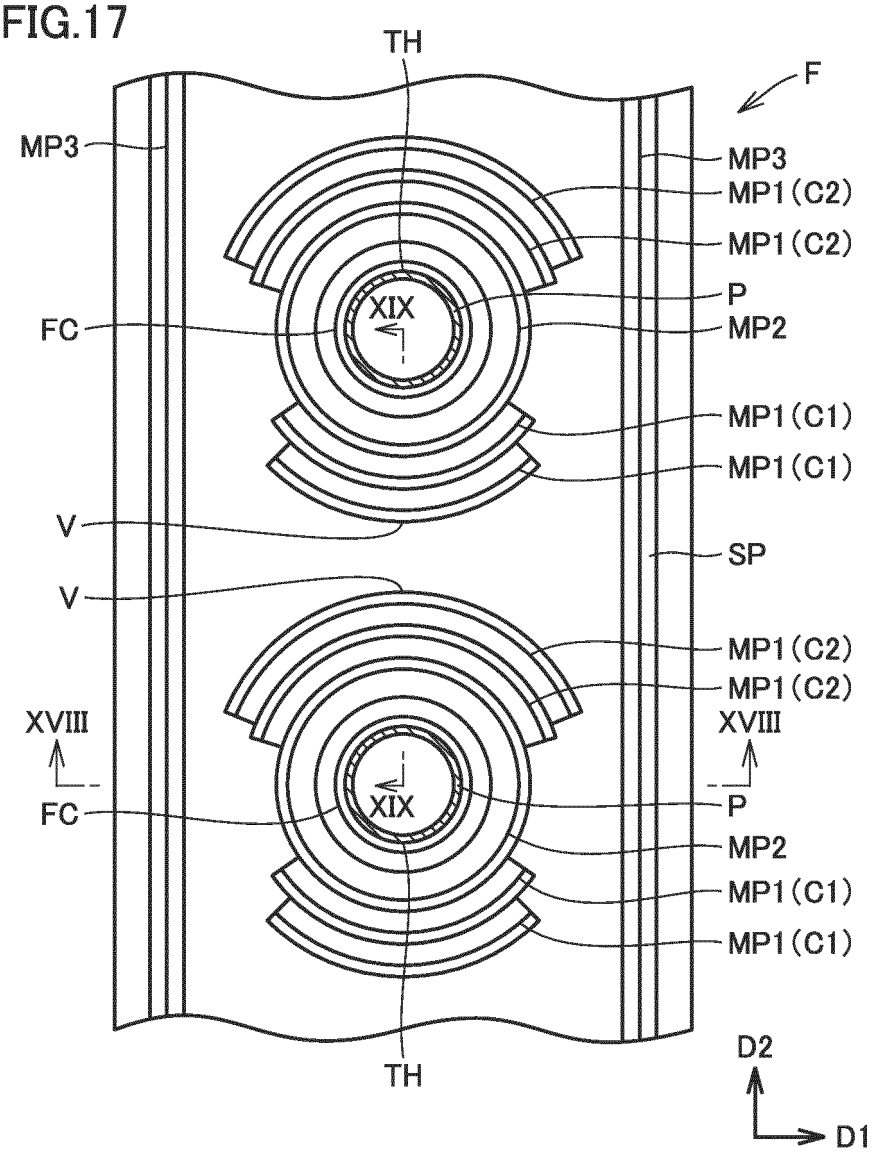

TH
F
MP3
MP3
MP1(C2)
MP1(C2)
P
XIX
FC
MP2
MP1(C1)
MP1(C1)
V
SP
V
MP1(C2)
MP1(C2)
XVIII
XVIII
XIX
FC
P
MP2
MP1(C1)
MP1(C1)
TH
D2
D1

FIG.18

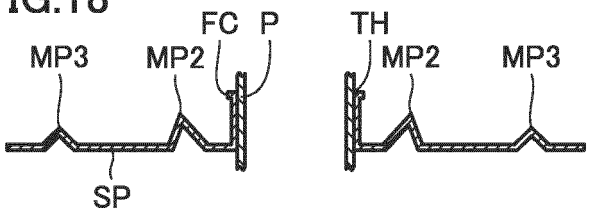
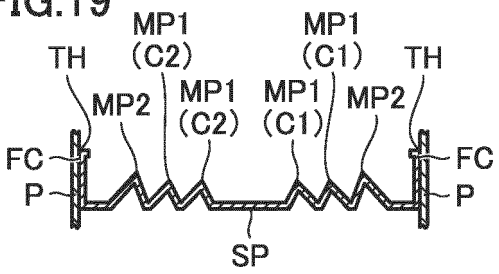


FIG.19



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/044334

A. CLASSIFICATION OF SUBJECT MATTER
F28F 1/32(2006.01)i
FI: F28F1/32 L

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F28F1/32

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922–1996
Published unexamined utility model applications of Japan	1971–2020
Registered utility model specifications of Japan	1996–2020
Published registered utility model applications of Japan	1994–2020

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 106111/1980 (Laid-open No. 30591/1982) (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 17 February 1982 (1982-02-17) specification, page 2, line 17 to page 3, line 5, fig. 2	1-9
A	JP 2019-163909 A (TOKYO ELECTRIC POWER COMPANY HOLDINGS, INC.) 26 September 2019 (2019-09-26) paragraphs [0021]-[0023], fig. 1	1-9

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 December 2020 (11.12.2020)	22 December 2020 (22.12.2020)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/044334

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 106109/1980 (Laid-open No. 30589/1982) (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 17 February 1982 (1982-02-17) specification, page 3, lines 1-14, fig. 1	1-9

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/044334

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 57-30591 U1	17 Feb. 1982	(Family: none)	
JP 2019-163909 A	26 Sep. 2019	(Family: none)	
JP 57-30589 U1	17 Feb. 1982	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2005077083 A **[0002] [0003]**